**CRJ-700 Alerting Issues – Single engine failure/fire**

**1. Initiating Condition: Engine failure after V1 and prior to V2**

| Type | Alert or cue | Threshold for alert or cue to be presented | Confusion regarding alert or cue | Other issues with regard to alert or cue | When alert is inhibited/suppressed or when cue is masked | How alert or cue is terminated |
|---|---|---|---|---|---|---|
| **Visual Alerts** | Master warning lights on glareshield | Presence of "L or R ENG FLAMEOUT" trigger for amber caution message | | | | Cancelled by pressing the light switch |
| | EICAS "L or R ENG FLAMEOUT" | $N_2$ core speed drops below a determined speed triggering this alert if FADEC unable to re-light and thrust lever not in shut-off. | Caution needed for reading correctly left vs. right engine has flamed out | | | |
| | "APR" icon appears inside thrust gauge | Engine $N_1$ speed decreases below 15% of the set power. APR system activates | | | | |
| | "APR CMD SET" amber message | Indicates an uncommanded APR activation | | | | |
| | Master warning lights on glareshield | Presence of "L or R ENG OIL PRESS" trigger for red warning message | | | | Cancelled by pressing the light |
| | EICAS "L or R ENG OIL PRESS" | Oil pressure below 25 psi | | | | |
| **Aural Alerts** | "Engine Oil" aural (voice) | Oil pressure below 25 psi | Failure to realize that an engine has failed prior to any oil pressure problem. This as opposed to just a low oil pressure indication only. Could be misdirected. | | | |
| **Tactile Alerts** | None | | | | | |

**CRJ-700 Alerting Issues – Single engine failure/fire**

1. Initiating Condition: Engine failure after V1 and prior to V2 – Cont.

| Type | Alert or cue | Threshold for alert or cue to be presented | Confusion regarding alert or cue | Other issues with regard to alert or cue | When alert is inhibited/suppressed or when cue is masked | How alert or cue is terminated |
|---|---|---|---|---|---|---|
| **Visual Cues** | Abnormal EGT, Abnormal N1 and/or N2, Abnormal oil pressure and temperature (low), Abnormal fuel flow (low). | Sensed value of respective parameter | May see any of this first and not appreciate first that an engine has failed as well which is producing these indications. | | | |
| | Nose yawing off runway centerline | | Misinterpreted as blown tire, steering issues and or locked brake event | | | |
| **Aural Cues** | Sounds of engine malfunction may occur | | Can be misinterpreted for other events | | | |
| **Tactile/ Somatic Cues** | Lateral g | | | | | |
| | Rudder pressure required to stay on runway | | | | | |

**Expected Pilot Response(s)**

- Control the aircraft e.g. maintain runway centerline and adjust pitch for reduced performance
- Ensure max thrust has ben set by APR and FADEC system
- Execute V1 engine failure/fire flight profile
- Execute single engine takeoff/climb profile
- Identify and execute appropriate non-normal checklist
- Perform single engine approach and landing, considering operational limitations as suggested by the QRH
- APR thrust is limited to 10 minutes only or engine damage may occur.
- Start APU if available
- If fire cannot be extinguished, expedite landing

**CRJ-700 Alerting Issues – Single engine failure/fire**

1. Initiating Condition: Engine failure after V1 and prior to V2 – Cont.

**Possible sources of confusion with regard to pilot response(s)**

- Stress, time pressure, startle.
- Confusion among engine surge, engine failure, tire blowout.
- Partial engine failure may present difficult diagnosis and decision as to whether to shut down.
- After reaching safe altitude and while considering the NNP to execute, possible confusion in deciding between two NNPs: ENG FLAMEOUT (which is annunciated on EICAS) and ENG SVR DMG/SEP, which is unannunciated and requires suppression of the ENG FAIL procedure as part of its own NNP)
- Numerous EICAS cautions/warnings occur due to a partially or completely failed engine. These can be confusing as to what is causing these especially when an engine partially fails in a non-obvious way.

**How does pilot know condition is resolved/recovered?**

- In the case of a simple flameout, successful re-starting of the engine resolves the immediate situation. Otherwise, the situation will not be resolved until the aircraft is landed.

**Issues with regard to multiple concurrent non-normal conditions**

- Engine failure presents concurrent electrical, hydraulic, and/or fuel system alerts, cues that may require additional action.
- Uncontained engine failure may present additional multiple alerts and failures.
- Uncontained engine failure may damage pressure vessel thus causing depressurization and a whole host of other issues.

**CRJ-700 Alerting Issues – Single engine failure/fire**

**2. Initiating Condition: Engine failure in flight with autopilot engaged**

| Type | Alert or cue | Threshold for alert or cue to be presented | Confusion regarding alert or cue | Other issues with regard to alert or cue | When alert is inhibited/suppressed or when cue is masked | How alert or cue is terminated |
|---|---|---|---|---|---|---|
| **Visual Alerts** | Master warning lights on glareshield | Presence of "L or R ENG FLAMEOUT" trigger for amber caution message | | | | Cancelled by pressing the light switch |
| | EICAS "L or R ENG FLAMEOUT" | $N_2$ core speed drops below a determined speed triggering this alert if FADEC unable to re-light and. Unable to find what core speed that this occurs. | Caution needed for reading correctly left vs. right engine has flamed out | | | |
| | "APR" icon appears inside thrust gauge if aircraft still considered being in takeoff mode. Determined by the TOGA as the last selection. | Engine $N_1$ speed decreases below 15% of the set power. APR system activates | | | | |
| | "APR CMD SET" amber message | Indicates an uncommanded APR activation | | | | |
| | Master warning lights on glareshield | Presence of "L or R ENG OIL PRESS" trigger for red warning message | | | | Cancelled by pressing the light switch |
| | EICAS "L or R ENG OIL PRESS" | Oil pressure below 25 psi | | | | |
| **Aural Alerts** | "Engine Oil" aural | Oil pressure below 25 psi | Failure to realize that an engine has failed prior to any oil pressure problem. This as opposed to just a low oil pressure indication only. Could be misdirected. | | | |
| **Tactile Alerts** | None | | | | | |

**CRJ-700 Alerting Issues – Single engine failure/fire**

2. Initiating Condition: Engine failure in flight with autopilot engaged – Cont.

| Type | Alert or cue | Threshold for alert or cue to be presented | Confusion regarding alert or cue | Other issues with regard to alert or cue | When alert is inhibited/suppressed or when cue is masked | How alert or cue is terminated |
|---|---|---|---|---|---|---|
| **Visual Cues** | Abnormal EGT, Abnormal N1 and/or N2, Abnormal oil pressure and temperature (low), Abnormal fuel flow (low). | Sensed value of respective parameter | May see any of this first and not appreciate first that an engine has failed as well which is producing these indications. | | | |
| | Slip/skid indicator showing uncoordinated flight | | | | | |
| **Aural Cues** | Sounds of engine malfunction may occur | | Can be misinterpreted for other events | | | |
| **Tactile/ Somatic Cues** | Lateral g | | | | | |

**Expected Pilot Response(s)**

- Control the aircraft, trim in required amount of opposite rudder. In this aircraft AP needs help with trim in this situation.
- Ensure max thrust has ben set by APR and FADEC system
- Execute single engine takeoff/climb profile if right after takeoff or consider drift down altitude if at cruise.
- Identify and execute appropriate non-normal checklist
- Start APU if available, if not must consider max altitude for single pack operations (FL250)
- Perform single engine approach and landing, considering operational limitations as suggested by the QRH

**Possible sources of confusion with regard to pilot response(s)**

- Stress, time pressure, startle.
- Confusion among engine surge, engine failure
- Partial engine failure may present difficult diagnosis and decision as to whether to shut down.
- After reaching safe altitude and while considering the NNP to execute, possible confusion in deciding between two NNPs: ENG FLAMEOUT (which is annunciated on EICAS) and ENG SVR DMG/SEP, which is unannunciated and requires suppression of the ENG FAIL procedure as part of its own NNP)
- Numerous EICAS cautions/warnings occur due to a partially or completely failed engine. These can be confusing as to what is causing these especially when an engine partially fails in a non-obvious way.

**CRJ-700 Alerting Issues – Single engine failure/fire**

2. Initiating Condition: Engine failure in flight with autopilot engaged – Cont.

**How does pilot know condition is resolved/recovered?**

- In the case of a simple flameout, successful re-starting of the engine resolves the immediate situation. Otherwise, the situation will not be resolved until the aircraft is landed.

**Issues with regard to multiple concurrent non-normal conditions**

- Engine failure presents concurrent electrical, hydraulic, and/or fuel system alerts, cues that may require additional action.
- Uncontained engine failure may present additional multiple alerts and failures.
- Uncontained engine failure may damage pressure vessel thus causing depressurization and a whole host of other issues.

**CRJ-700 Alerting Issues – Single engine failure/fire**

**3. Initiating Condition: Engine fire after V1 and prior to V2**

| Type | Alert or cue | Threshold for alert or cue to be presented | Confusion regarding alert or cue | Other issues with regard to alert or cue | When alert is inhibited/suppressed or when cue is masked | How alert or cue is terminated |
|---|---|---|---|---|---|---|
| **Visual Alerts** | Master warning lights on glareshield | Presence of "L or R ENG FIRE" trigger for red warning message | | Many other EICAS warning messages could push this off the bottom of the screen and then could but seen upon page 2 manual selection. From the FCOM *"If the number of warning messages exceeds the available message area, only the most recent will be displayed."* | NOT inhibited during any part of flight | Cancelled by pressing the light switch |
| | EICAS warning message "FIRE ENG L or R" | Temperature sensed by both engine fire loops | Confusion between fire with and without engine failure | | If both loops are burned through, will change to "L or R FIRE FAIL" amber message and corresponding amber caution and single chime. | Lower temperature sensed by both engine fire loops |
| | LH or RH ENG Fire push switchlight illuminated | Temperature sensed by both engine fire loops | Confusion between fire with and without engine failure | | If both loops are burned through, will change to "L or R FIRE FAIL" amber message and corresponding amber caution and single chime. | When push light switch is selected |
| | EICAS Caution "ENG BTL 1 or 2 (eventually) LO" | Pressure in bottle decreases below a preset value. | Crew might think that bottle has a leak and has not discharged into the engine compartment | | | Does not until MX is performed |
| **Aural Alerts** | Triple chime master warning | Presence of "L or R ENG FIRE" trigger for red warning message | | | | Selection of master warning switchlight |

**CRJ-700 Alerting Issues – Single engine failure/fire**

3. Initiating Condition: Engine fire after V1 and prior to V2 – Cont.

| Type | Alert or cue | Threshold for alert or cue to be presented | Confusion regarding alert or cue | Other issues with regard to alert or cue | When alert is inhibited/suppressed or when cue is masked | How alert or cue is terminated |
|---|---|---|---|---|---|---|
| **Aural Alerts** | Fire bell | Presence of "L or R ENG FIRE" trigger for red warning message | | | | Selection of fire push switchlight |
| | Single chime master caution | Presence of "L or R BTL 1 or 2 LO" EICAS message | | This only occurs once a fire bottle has been discharged and the internal pressure drops below a preset value | Inhibited? | Selection of master caution switchlight |
| **Tactile Alerts** | None unless engine also fails | | | | | |
| **Visual Cues** | Possible abnormal EGT, Possible abnormal N1 and/or N2, Possible abnormal oil pressure and temperature (low), Possible abnormal fuel flow (low) | Sensed value of respective parameter and depends on the degree of fire suppression and extent of damage. | May see any of this first and not appreciate first that an engine has failed as well which is producing these indications. | | | |
| | Slip/skid indicator showing uncoordinated flight if the engine has partially or completely failed | | | | | |
| **Aural Cues** | Sounds of engine malfunction may occur | | Can be misinterpreted for other events | | | |
| **Tactile/ Somatic Cues** | None unless engine also fails | | | | | |

**CRJ-700 Alerting Issues – Single engine failure/fire**

3. Initiating Condition: Engine fire after V1 and prior to V2 – Cont.

**Expected Pilot Response(s)**

- Control the aircraft, trim in required amount of opposite rudder. In this aircraft AP needs help with trim in this situation if the engine has failed. Or upon shut-down, adjust trim as needed
- Ensure max thrust has ben set by APR and FADEC system if engine has failed as well. If not, upon shut down, ensure correct thrust set for remaining engine
- Execute V1 engine failure/fire flight profile
- Execute single engine takeoff/climb profile
- Execute memory items for engine fire after reaching safe altitude
- Identify and execute appropriate emergency checklist
- Start APU if available as directed by checklist
- Perform single engine approach and landing, considering operational limitations as suggested by the QRH
- If fire cannot be extinguished, expedite landing

**Possible sources of confusion with regard to pilot response(s)**

- Stress, time pressure, startle.
- Confusion among engine surge, engine failure
- Numerous EICAS cautions/warnings occur due to a partially or completely failed engine. These can be confusing as to what is causing these especially when an engine partially fails in a non-obvious way.
- False fire warning cannot readily be distinguished from valid fire warning (see condition 4 below).

**How does pilot know condition is resolved/recovered?**

- After completion of emergency checklist, hopefully fire will be extinguished and acute situation resolved. However, if after checklist completion including both bottles being discharged, fire may still be present. Then, situation is not resolved until landing and extinguishment by ARFF crews.

**Issues with regard to multiple concurrent non-normal conditions**

- Engine fire will devolve to an engine failure, either as a direct result of and simultaneous with the fire onset or as part of the engine fire procedure.
- Engine fire presents concurrent electrical, hydraulic, and/or fuel system failures that may require additional action.
- Engine fire may present cascading emergency (e.g., hydraulic failures, smoke in cabin, etc.)
- Uncontrollable fire may present additional, cascading conditions (e.g., structural failure, fuel loss, need to expedite landing or even land off-airport).
- Uncontained engine failure may present additional multiple alerts and failures.

**CRJ-700 Alerting Issues – Single engine failure/fire**

**4. Initiating Condition: False fire warning from engine bleed leak, during takeoff after V1 and before V2**

| Type | Alert or cue | Threshold for alert or cue to be presented | Confusion regarding alert or cue | Other issues with regard to alert or cue | When alert is inhibited/suppressed or when cue is masked | How alert or cue is terminated |
|---|---|---|---|---|---|---|
| **Visual Alerts** | Master warning lights on glareshield | Presence of "L or R ENG FIRE" trigger for red warning message | Warning is false, there is no fire. There are no salient cues to the fact that there is no fire; absence of engine failure is not, in itself, diagnostic of a false fire warning. | False fire warning can lead to unneeded RTO, engine shutdown, etc. | | Cancelled by pressing the light switch |
| | EICAS warning message "FIRE ENG L or R" | Temperature sensed by both engine fire loops | Warning is false, there is no fire. There are no salient cues to the fact that there is no fire; absence of engine failure is not, in itself, diagnostic of a false fire warning. | False fire warning can lead to unneeded RTO, engine shutdown, etc. | | Lower temperature sensed by both engine fire loops |
| | LH or RH ENG Fire push switchlight illuminated | Temperature sensed by both engine fire loops | Warning is false, there is no fire. There are no salient cues to the fact that there is no fire; absence of engine failure is not, in itself, diagnostic of a false fire warning. | False fire warning can lead to unneeded RTO, engine shutdown, etc. | | When push light switch is selected |
| | EICAS Caution "ENG BTL 1 or 2 (eventually) LO" | Pressure in bottle decreases below a preset value. | Crew might think that bottle has a leak and has not discharged into the engine compartment | | | Does not until MX is performed |
| **Aural Alerts** | Triple chime master warning | Presence of "L or R ENG FIRE" trigger for red warning message | | | | Selection of master warning switchlight |
| | Fire bell | Presence of "L or R ENG FIRE" trigger for red warning message | | | | Selection of fire push switchlight |
| | Single chime master caution | Presence of "L or R BTL 1 or 2 LO" EICAS message | | This only occurs once a fire bottle has been discharged and the internal pressure drops below a preset value | | Selection of master caution switchlight |

**CRJ-700 Alerting Issues – Single engine failure/fire**

4. Initiating Condition: False fire warning from engine bleed leak, during takeoff after V1 and before V2 – Cont.

| Type | Alert or cue | Threshold for alert or cue to be presented | Confusion regarding alert or cue | Other issues with regard to alert or cue | When alert is inhibited/suppressed or when cue is masked | How alert or cue is terminated |
|---|---|---|---|---|---|---|
| **Tactile Alerts** | None | | | | | |
| **Visual Cues** | None | | | | | |
| **Aural Cues** | None | | | | | |
| **Tactile/Somatic Cues** | None | | | | | |

**Expected Pilot Response(s)**

- Control the aircraft, trim in required amount of opposite rudder. In this aircraft AP needs help with trim in this situation when an engine is shut-down
- Ensure max thrust has ben set by APR and FADEC system when engine is shut-down
- Execute V1 engine failure/fire flight profile
- Execute single engine takeoff/climb profile
- Execute memory items for engine fire after reaching safe altitude
- Identify and execute appropriate emergency checklist
- Start APU if available as directed by checklist
- Perform single engine approach and landing, considering operational limitations as suggested by the QRH
- If fire cannot be extinguished, expedite landing

**Possible sources of confusion with regard to pilot response(s)**

- Stress, time pressure, startle.
- False fire warning cannot readily be distinguished from valid fire warning (see condition 3 above).

**Issues with regard to multiple concurrent non-normal conditions**

- If crew performs the NNP in response to the false warning of an engine failure, either as a direct result of and simultaneous with the fire onset or as part of the engine fire procedure.
- If false indication of fire continues after engine fire NNPs are performed, pilot concerns about inextinguishable fire may prompt risky alternative actions (e.g., rushing, off-airport landing, etc.)